THE CONTRIBUTION OF ALFRED BARRETT BIGGS TO AUSTRALIAN AND TASMANIAN ASTRONOMY

Wayne Orchiston
Faculty of Applied Science, Victoria College (Rusden Campus)
Clayton, Victoria

Manuscript received 12/6/84 *Published 23/9/85*

After Francis Abbott, Alfred Barrett Biggs (1825-1900) was Tasmania's most prominent nineteenth century astronomer. Although an amateur, he maintained two observatories, one of which functioned as a *de facto* city observatory. It housed a 216 mm reflector, which was furnished with a micrometer. This instrument, and a 76 mm refractor in the other observatory, were used for a variety of observational programmes in which comets and double stars featured most prominently. Biggs published a number of papers outlining the results of his research.

Any evaluation of Biggs's role in Australian and Tasmanian astronomy must involve far more than just observational astronomy and publications, for he was also addicted to the notion of public astronomy, and was a prominent pioneer in the popularization of the science. In addition, Biggs brought a remarkable suite of optical and mechanical skills to astronomy, and he also applied these to his other major scientific interest, seismology, in which he was an Australian pioneer. Alfred Barrett Biggs played an important role in the development of nineteenth century astronomical and earth sciences in Australia.

INTRODUCTION

In the history of Australian astronomy two periods stand out as particularly important:

1. 1850-1899, when the State observatories were established (Baracchi 1914; Ellery 1901), the earliest astronomical societies formed (Orchiston 1982a; Orchiston and Bhathal 1984), and the first "home grown" telescope-makers appeared (Orchiston 1983b); and
2. 1945-Present, with the flowering of astronomy courses and observatories through the universities, the establishment of an impressive range of facilities at Siding Spring, and the phenomenal growth of radio astronomy (Expert Committee 1978; Pawsey 1961; Wild 1972; Wood 1973).

Despite the chronological gap, there are marked parallels between these two periods, as increasing government funding came to the aid of astronomy, and as new techniques were

warily tested and perfected. In the nineteenth century the important innovation was the photographic plate, and the culmination of its use came with the adoption of the Carte du Ciel project by the State observatories at Melbourne, Perth and Sydney. By contrast, in the present era we are witnessing the exciting marriage of astronomy, electronics and computing.

Although there are some basic similarities between the two periods, there is, however, one area in which the pattern of involvement differed markedly, and that is in the contribution of the amateur astronomer. During the second half of the nineteenth century and through to World War II the number of amateur astronomers, in proportion to professionals, carrying out worthwhile research and publishing, was significantly greater than is the case today (see Orchiston 1983b : 3-4).

The doyen of the amateurs was that famous New South Welshman, John Tebbutt of Windsor (see Ashbrook 1972; Baracchi 1914 : 351-354; Kimpton 1980; McDonagh and Orchiston 1961; Orchiston 1968, 1981, 1982a, 1982b; White 1979), but there were many others of lesser renown. The great majority of these were resident in the New South Wales (mainly Sydney) area, but Victoria could boast their famous comet-discoverer, David Ross (Orchiston and Bhathal n.d.), and Dr. William Bone of Castlemaine (see Orchiston 1982b).

Considering its small population, Tasmania had a comparatively large contingent of "significant" amateur astronomers, with two individuals rating special mention in Baracchi's pioneering study. They were Francis Abbott of Hobart and Alfred Barrett Biggs of Launceston. Abbott is well known to any student of Australian astronomy, but few would be familiar with Biggs's name. Baracchi (1914:356) deals with him in just a few lines, and he receives similar treatment by McAulay (1902). Hopefully, this situation will be redressed in the present paper.

Research on Biggs took the author in person or by letter to archival collections in Hobart, Launceston, Melbourne, Canberra, Sydney and Washington. It also involved a literature survey, oral history studies with elderly surviving descendents, and a voluminous correspondence. Undoubtedly the greatest source of data for the study proved to be the letters written by Biggs to John Tebbutt, now housed in the "Tebbutt Collection" in the Mitchell Library, Sydney. These were systematically abstracted during intermittent trips to Sydney in 1981 and 1982. A seminar held in Launceston on 5 November 1983 to mark the centenary of instrumental seismology in Australia (of which Biggs was the founder) marked the first opportunity for the fruits of these labours to be brought together, and for the occasion a short paper was prepared on Biggs's astronomical work, designed largely for a non-astronomical audience (Orchiston 1984b). This present paper is a much more definitive account, an abridged version of which was delivered in April 1984 at the Perth convention of amateur astronomers (Orchiston 1984a).

ALFRED BARRETT BIGGS: FROM EMBRYO TO EMBRYONIC ASTRONOMER

Biographical Sketch

Alfred Barrett Biggs (Plate 1) was born in London on 10 April 1825 to Abraham and Eliza Biggs. He was the second of their twelve children (Biggs Family Tree). The family migrated to Hobart in 1833 and after three years as a businessman, Abraham turned his talents to farming (A. Biggs 1834, 1835, 1837).* In 1837, while farming at Colebrook, Abraham Biggs began school teaching and conducting Methodist church services, and in the following year young Alfred Barrett, then aged 13, began assisting his father at the school (A. Biggs 1838).

Clearly Alfred Barrett Biggs gained his education directly from his father. It is therefore not surprising that he also chose a teaching career, and in 1845 we find him moving from the family home (then at Richmond, Tasmania) to take up a tutoring post at Bothwell (Biggs 1848). In 1852 he left Tasmania, for a tutorship in Melbourne, and spent eleven happy years on the mainland. It was during this period that he married Harriet Burville (on 22 February 1855).

Despite the advantages and excitement of urban life in a city flush with gold-fever, Biggs's heart lay in the Tasmanian countryside, and it is no surprise, therefore, that he accepted the

Plate 1
Alfred Barrett Biggs (1825-1900)

Tasmanian Board of Education's offer of a posting, in November 1863 (Biggs 1863). His new school lay in familiar territory: the town of Bothwell.

Biggs's next appointment was to the public school at Campbell Town in 1872 (Historical Committee . . . 1966:43), and it was there that his interest in astronomy blossomed. However, his teaching career came under a cloud when he fell foul of an influential local clergyman, and he was obliged to quit the school at the end of 1874 (*ibid.*:44-45). Precisely what he did and where he lived from 1875 to 1879 (inclusive) is not known, and the single crucial event during this period which should provide a solution gives conflicting accounts. This relates to Biggs's successful attempt in 1878 to send the first telephone messages in Australia. Some accounts of the event suggest he was living in Launceston at this time while other versions favour Campbell Town (A. W. Biggs 1933; R. A. Biggs, pers.comm.,1983;Meston 1933:27). It seems, on the basis of his astronomical observations, that he moved from Campbell Town to Launceston in 1877 or early 1878. Whatever the case, we know that Biggs abandoned teaching some time between 1875 and 1880, as he turned to a new profession in the latter year.

His new post was as accountant and head ledger-keeper at the Launceston Bank for Savings, in Launceston (Beever 1972:96), which brought with it free accommodation above the Bank (then located in Paterson Street — see Fig. 1). Biggs's favourite associate at the Bank was the actuary, George Pullen (Beever 1972:74-75), who was his brother-in-law. Biggs remained with the Bank until December 1900 when ill health forced his retirement, and he died less than three weeks later, on the 19th. He was 75 years of age (Obituary . . . 1900). He was predeceased by his wife, but left a family of one son and five daughters (Biggs Family Tree). He was buried in the General Cemetery in Launceston.

Introduction to the Fascinating World of Astronomy

It would seem that astronomy was a topic of conversation from time to time in Abraham Biggs's household if a letter dating to 1837 is any indication. In responding to his brother's queries, Abraham (Alfred's father) writes:

> The comet I can say nothing about at present. The Northern Lights I have not heard of here.

It is therefore reasonable to assume that Alfred Barrett derived a passing interest in astronomy through his father, in the course of his general education (although there is no direct evidence for this). What does emerge, though, in a survey of the archival sources, is that Alfred's interest in astronomy received a major boost while he was living in Campbell Town. Two catalysts were responsible for this metamorphosis: Dr. William Valentine, and the 1874 Transit of Venus.

Dr. Valentine, some 17 years Biggs's senior, was born in Somerset, England, and migrated to Tasmania in 1839, settling in Campbell Town. Biggs and Valentine shared a catholic interest in scientific matters and both were accomplished musicians and staunch churchmen (Historical Committee . . . 1966:44,140,179). When Biggs moved to Campbell Town, Valentine was living in a mansion known as "The Grange", which came complete with small observatory. Shortly before he died in 1876 Valentine installed a 216 mm Browning-With reflector (Biggs 1882c). Biggs and Valentine struck up an instant friendship, and Biggs's interest in astronomy developed rapidly in the prevailing congenial academic climate.

An important supplementary influence was the 1874 Transit of Venus. One of the American research teams originally assigned to the Crozet Islands (southeast of Africa) ended up in Tasmania, and accepted Dr. Valentine's invitation to set up their observing station at The Grange. The party of five reached Campbell Town on 10 October, and in the course of the following weeks prefabricated transit, photographic and equatorial "houses" were erected, and associated instruments installed and tested, in readiness for the 9 December event. A clock station was also established in Dr. Valentine's house. Biggs offered assistance to the Americans during their preparations, and was subsequently appointed "recorder" in the

**Unless indicated otherwise, all subsequent text references listed simply as "Biggs" relate solely to Alfred Barrett Biggs.*

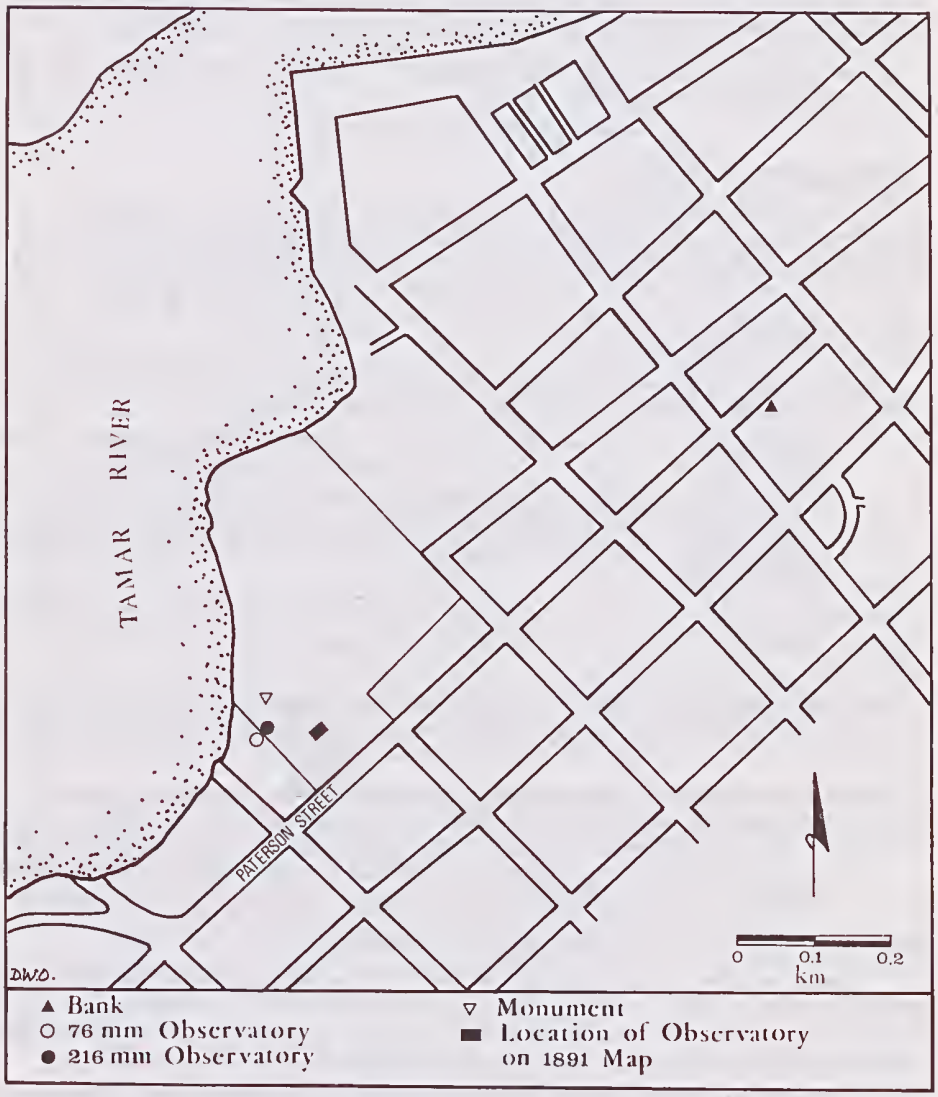

Fig. 1
Map of Launceston, showing the location of Biggs's two observatories and the Launceston Bank for Savings (this is a revised version of an earlier map in Orchiston 1984b)

photographic house for the transit. He was one of three local volunteers to participate (Raymond n.d.:383), and carried out his duties diligently . Somehow, he also found time to observe the transit visually with his own little telescope, a mere 51 mm refractor (Biggs 1881f).

In spite of inclement weather during part of the transit, a large number of photographs were obtained at Campbell Town (Raymond n.d.:386), and Todd (1881) used some of these, and those from other stations, to derive a parallax of 8."883 ± 0.034 for the Sun.

In recognition of his services, the Americans gave Biggs the "transit house" when they left Campbell Town (Meston 1933).

OBSERVATIONAL EQUIPMENT

Telescopes and Accessories

The first telescope that Biggs acquired, for which we have any record, was the little 51 mm refractor which he used to observe the Transit of Venus in 1874. There are no descriptions of this instrument, other than that it was a "very good" telescope (Biggs 1881f), but since Biggs kept it at the Bank (rather than in one of his observatories) while living in Launceston (Biggs 1881g), it would seem to have been a portable instrument devoid of any mounting, and was possibly a marine telescope.

Some time after the Transit, but by 1878, Biggs acquired a 76 mm refracting telescope. He describes this instrument in a letter to John Tebbutt dated 13 May 1882:

> My telescope is a refractor of 3 inches aperture, or say 2.9" clear of all stops. I . . . [am] satisfied with its quality . . . It is mounted equatorially, (by myself) roughly of course, but effectively, with careful adjustment of the axes in all respects, and provided with circles roughly divided but sufficiently to set it at once upon any object I am seeking in any position. It is perfectly steady with all powers. I have 5 or 6 powers ranging from about 35 to 271.

When Biggs settled in Launceston, this telescope was mounted on a stone pier, about 1.5 metres in height (A. W. Biggs 1933), and late in 1881 Biggs completed a drive for it (Biggs 1881f).

We also know that by May 1878 Biggs had fitted out this telescope with a reticle micrometer of his own design (Biggs 1882a). This device was adapted from an earlier version that he had built to use with his microscope (and this is described in Biggs 1868a, 1868b).

Soon after moving to Launceston, Biggs also added a transit telescope of sorts to his instrumental stable. This home-made instrument is described by Biggs (1882c) as

> . . . nothing to speak of. That too is my own make and is only capable of giving me a clear approximation for time (say 1 or 2 seconds) but is too small and altogether inadequate to determine adequately the position of any object. (His underlining).

Just where (or how) this transit instrument was mounted cannot be established.

The next notable addition to Biggs's range of instruments was a bar micrometer built to replace the reticle version of 1878, which proved to give erroneous results when used on double stars. Tebbutt was quick to point out the advantages of a filar micrometer, but this presented problems for Biggs. In a letter to Tebbutt dated 21 April 1882 he writes:

> The procuring of a filar Mic[r]. means, as I fear, considerable expense, which I can ill afford, and also much delay, which I can ill brook . . .

Biggs therefore chose to build his own micrometer, and just one and a half months later was carrying out his first observations with the new device, attached to the 76 mm telescope (Biggs 1882d, 1882e). Following certain criticisms by Tebbutt, Biggs was obliged (1882h) to carry out some minor modifications to the micrometer in September 1882, and thereafter it served as a very useful instrument in his double star and comet programmes. After observing double stars with a professional filar micrometer at Melbourne Observatory in March 1883,

Biggs (1883c) was able to report to Tebbutt that his own micrometer was ". . . capable of working with at least equal accuracy . . .". Despite this, Biggs made further minor modifications the following year (Biggs 1884a), and eventually described the instrument in a paper published by the Royal Society of Tasmania (Biggs 1889b).

Undoubtedly Biggs's most important new acquisition of the 1880s was a 216 mm reflecting telescope which he was given by a friend, Mr. John Taylor of Campbell Town (see Historical Committee . . . 1966;102,152) in mid-1885 (Biggs 1885b). This was the very same instrument that Biggs had used many years earlier at Dr. Valentine's observatory, and after Valentine's death in 1876 it was acquired by Taylor (Biggs 1882c). John Taylor only used the instrument occasionally during the ten years that he owned it (see Biggs 1882a, 1882c). Biggs provided Tebbutt with an account of this telescope on 31 July 1885:

> . . . by the noble generosity of a friend, I am put in possession of a more powerful instrument, namely an 8½ inch Reflector — (Browning-With) . . . It is mounted equatorially (approximately) by its former owner, but without circles . . . It is provided with Browning's powers N^OS 1, 3, 5, also G achromatic and a position spider-line eye-piece. Also Barlow-lens, and diagonal Sun-prism.

From a contemporary newspaper account we learn that this telescope was a Newtonian, with a focal ratio of about 9. But, despite its impressive size and appearance this instrument was described as ". . . not so handy or so well fitted up as Mr Biggs' old one, which is a model of completeness and mechanical skill". (The largest telescope . . . 1885). Nevertheless, it was the largest and most powerful telescope in Tasmania, at that time, and as such was seen as ". . . a great acquisition to the town . . ." (*ibid.*).

Biggs immediately set to work on a number of instrumental modifications to bring the telescope up to the operational standard that he required for his observations. By early October he had installed new circles, complete with verniers (Biggs 1885c). He also manufactured a drive, inventing an ingenious water-clock with a four gallon drum, a massive float, and an array of pulleys (A. W. Biggs n.d.).

The 216 mm telescope also benefited in 1888 when Biggs finally ordered a state-of-the-art Troughton and Sims filar micrometer from England (Biggs 1888b; A. W. Biggs 1901), but he was soon able to demonstrate that his home-made bar micrometer (which had been adapted for use with the big reflecting telescope) was the equal of the new professional instrument (Biggs 1889d).

Given the makeshift nature of Biggs's home-made transit telescope, it is not surprising that he obtained a second instrument — this time a professionally-made one — some time during the 1880s. This was acquired on loan through the generosity of R. L. J. Ellery, the Government Astronomer of Victoria (A. W. Biggs 1933).

The aforementioned instruments, plus a marine chronometer, a small sextant, and a 1.5 metre high master electric clock (Biggs 1882c; A. W. Biggs 1933), complete the survey of Biggs's telescopes and accessories. The manner in which these various instruments were housed will now be examined.

Observatories

Although Biggs received the American party's "Transit House", as appreciation for assistance he rendered during the 1874 Transit of Venus, there is no evidence that this was subsequently put to use while he lived in Campbell Town. It has been suggested elsewhere (Orchiston 1984b) that he may have constructed some form of primitive shelter for the 76 mm telescope.

The first known permanent home of the 76 mm instrument was a small octagonal observatory with a dome, erected in George Pullen's garden soon after the move to Launceston (Biggs 1882f, 1886d). It has been possible to pinpoint Pullen's residence through a title search, and Gwen Brown's recollections of her visits to the house early in the present

century: it was situated beside the Tamar River just off Paterson Street, about 0.8 km from the bank where Biggs lived (see Figure 1).

The siting of the observatory was far from ideal, as Biggs (1881e) pointed out to Tebbutt:

> My little Observatory is very unfavourably situated, as an adjacent roof cuts off several degrees of altitude eastwards, and a lofty hill, as well as trees in the Garden, serve the same office to the westward.

Given the locations of adjacent buildings in the Depot Grounds, to the east of Pullen's block of land, this quote allows us to place the observatory in the southeastern corner of the property, and the view of Launceston taken in 1885 or 1886 shown here in Plate 2 includes a small structure in this position (building "b", in the photograph). Apart from this information, no further details of the 76 mm observatory are available, nor were any close-up photographs, plans or drawings of it located.

With the arrival of the large reflecting telescope in 1885, Biggs was forced to construct another observatory, and this is described in a contemporary newspaper article:

> The instrument is set in an observatory built under Mr Biggs' directions the roof being movable, so as to observe either portions of the heavens by running it by means of pulleys backward or forward along the wall plates (The largest telescope . . . 1885; c.f. Scott and Scott 1935).

These accounts reveal that the new observatory was of the roll-off roof variety, and a letter from Biggs to Tebbutt written in 1886(b) indicates the roof was made of iron sheeting. According to legend, and repeated by Meston (1933) and in "The mathematical mind" (1935), this observatory comprised the "Transit House" given Biggs by the Americans, or parts of it.

The precise location of this roll-off roof observatory is still in dispute. At the time it was erected, the local newspaper reported it as ". . . on the ground adjoining the Invalid Depot, where an uninterrupted view can be obtained of the lowest spot in the horizon" (The largest telescope . . . 1885), in an area known as the "Depot Grounds", and now called Royal Park. The Depot Grounds abutted Pullen's property, and if we are to believe Meston (1933), the new observatory was built just across the fence from the 76 mm observatory. Nowhere in his publications or letters does Biggs make specific reference to the location of this observatory, but the original siting of the commemorative obelisk now in Royal Park (R. A. Biggs, *pers. comm.*, 1983) would support the position suggested by Meston, in the centre of what is now Park Street (see Figure 1). Moreover, Plate 2 shows in this position a conspicuous rectangular building, "c", which appears to have walls that are considerably longer than the associated roof. This is consistent with what would be expected in the case of a roll-off roof observatory.

Running counter to this interpretation is an 1891 map of Launceston in the Northern Regional Library which shows a rectangular building marked "Observatory" in quite a different position in the Depot Grounds*. This discrepant position is shown in Figure 1. A search through all available Launceston photographs of the 1885-1900 period in the Northern Regional Library in Launceston, the La Trobe Library in Melbourne and the Mitchell Library in Sydney failed to produce one instance of a building at the position in question; to the contrary, some photographs showed a pathway flanked by trees running diagonally across the Depot Grounds, and right through the purported position of the observatory. It seems that the 1891 map is misleading in that it does not show the true position of the observatory for the 216 mm telescope. It would seem that inclusion of the "Observatory" building was merely symbolic —to indicate that an astronomical observatory lay within (but *anywhere* within) the boundary of the Depot Grounds. Supporting this interpretation is the orientation of the "Observatory", which is not aligned north-south, as one would expect for a roll-off roof observatory building.

Unfortunately there is a great deal of confusing information in the twentieth century literature, particularly in press articles, regarding the two observatories. For the most part, this

I am grateful to Dennis Hodgkinson for bringing this to my attention.

Plate 2
Panoramic view of Launceston, circa 1886, showing Pullen's house and buildings identified with the two observatories (a = Pullen's House; b = 76 mm observatory; c = 216 mm observatory)

has been caused because writers were unaware that for 15 years Biggs maintained two quite separate, if neighbouring, observatories. Some writers, drawing on earlier accounts, have unwittingly mixed data derived from the two buildings, thereby adding to the confusion.

Fate of the Instruments and Observatories

Although the current whereabouts of Biggs's various telescopes is unknown, some information is available on what became of the instruments immediately after his death in 1900.

The large reflecting telescope was bequeathed to the Royal Society of Tasmania. The Society's Minutes of 21 February 1901 include the following letter from A. W. Biggs, a son of A. B. Biggs, dated 21 January:

> It is my duty to inform you that ... a codicil of his [i.e. A. B. Biggs's] will dated 14th Decr. 1900 reads "I bequeath my reflecting Telescope to the Royal Society of Tasmania ... With the Telescope will be included Case of eye pieces ... also one sun prism ... A Barlow lens is to be added to the above list. The valuable filar micrometer is not included in the gift of the Telescope, but is to be sold separately for the benefit of the family price ten pounds (£10) this having been a special purchase and subsequent addition to the instrument."

In his letter, A. W. Biggs went on to point out how his hands were tied regarding the price of the filar micrometer, and he hoped that the Society would agree to purchase it. He then proceeded to make a very interesting statement, regarding the telescope:

> Whilst we as a family would have preferred for it to be made good use of in the position he left it we have neither the wish nor the power to restrict what he most desired ... (His underlining).

Notwithstanding the family's views, the telescope was dismantled shortly afterwards and forwarded to Hobart, but only, it must be assumed, after its original donor (John Taylor of Campbell Town) gave his consent. There followed many months of intermittent discussion on what should become of the telescope, and on 19 November 1901 the Council of the Society resolved to loan it to the State Government's Meteorological Department. When they turned it down the instrument was offered to the University, and in September 1902 it was recorded that Professor McAulay from the Physics Department had taken charge of the telescope and insured it for one hundred pounds (Royal Society of Tasmania 1901-1902; see, also, McAulay 1902).

Nothing more is heard of the telescope until early in 1918 when A. W. Biggs pointed out to the Royal Society of Tasmania that they were not empowered to hand over the telescope to the University. The Society immediately decided to return the instrument, and on 18 February they received a letter from Mr. Biggs advising that it had arrived safely (Royal Society of Tasmania 1918).

A. W. Biggs then turned round and formally offered the telescope to the University, but on condition that:

1. damage done to it while originally in University hands was repaired;
2. it was suitably housed, and
3. it was likely to be frequently used for purposes of study.

This offer was considered by the University Council and the Faculty of Science, but with another larger telescope then also on offer to the University (John Dear's 305 mm reflector, complete with observatory) it was refused (University of Tasmania 1918).

The subsequent fate of the 216 mm telescope is obscure, although we do know that some time after 1918 it was shipped to Melbourne and sold through Sewards (even this much is only known because it appears as an addendum, in the hand of one of A. B. Biggs's grand daughters, to the Mitchell Library's copy of Meston's 1933 article). N. H. Seward was an active

amateur astronomer in Victoria during the 1930-1950 period, and ran a successful business in Bourke Street involving books and scientific instruments. The business closed more than ten years ago, and all attempts to track down the current owner of the Biggs Telescope have proved fruitless. Notwithstanding a detailed literature search, and various interviews with elderly Victorian amateur astronomers, its current whereabouts remains a mystery. Certainly, there is no basis for the version reported in the Campbell Town Centenary Publication that it ". . . is now on loan to the Hobart Astronomical Society by the University of Tasmania." (Historical Committee . . . 1966:180).

Unfortunately, we fare little better with the other telescopes in Biggs's observatories. The 76 mm refractor was bequeathed to Frank Thomas Biggs of Launceston (A. W. Biggs 1933), one of Alfred's nephews (Biggs Family Tree). Mr. R. A. Biggs of Hobart remembers looking through this telescope around 1910, when it was mounted in "Uncle Frank's" backyard at Inveresk, Launceston (*pers. comm.*,1983). Frank Biggs died in 1946 (Biggs Family Tree), and the telescope disappeared.

A similar fate has also befallen the 51 mm refractor and the original transit instrument, while the second transit telescope was apparently returned to Melbourne Observatory (A. W. Biggs 1933).

The fate of the two observatory buildings is equally obscure. Gwen Brown, who visited the Pullen house as a girl a number of times between 1911 and 1915, does not recall seeing any sort of observatory — even a derelict one — there (*pers. comm.*, 1981), and this structure was probably dismantled in 1901 when the refracting telescope was moved to Frank Biggs's home.

Nor is there any indication as to when the other observatory, in the Depot Grounds, was dismantled. Although the instruments were removed in 1901, it is possible that the building remained intact for a number of years, for *Walch's Tasmanian Almanac* continues to list a latitude and longitude for "Biggs' Observatory, Depot Grounds, Paterson Street" up to and including 1911. Thereafter, the positions are simply given for the "Depot Grounds" and eventually "Royal Park". Mr. Hodgkinson kindly provided this useful information.

Currently, all that remains in Launceston as a permanent reminder of Alfred Barrett Biggs and his achievements is a stone monument in Royal Park, adjacent to the Bowling Club (see Plate 3; Fig. 1). This is meant to mark the position of the 216 mm observatory building, but does not do so, as it was moved from its original location some years ago when a levee was raised along the river bank. The monument carries the following inscription:

LAT. 41° 26' 1" S.
LONG. 147° 7' 49.5" E.
SITE OF THE OBSERVATORY OF
A. B. BIGGS, ESQ.
ERECTED BY THE
ROYAL SOCIETY OF TASMANIA.
18TH SEPT. 1935.

OBSERVATIONAL PROGRAMMES

Introduction

Although Biggs carried out his first independent astronomical observations at Campbell Town, he only launched into serious observational astronomy after moving to Launceston, and continued to observe regularly through into the early 1890s when old age and failing eyesight began to take their toll.

His focus throughout was on comets and double stars, but he also paid attention to certain "current phenomena". An account and assessment of his observational achievements follows.

Plate 3
Obelisk in Royal Park relating to Biggs's 216 mm observatory.

Comets

The first comet that Biggs observed seriously was apparently the Great Comet of 1880 which he followed assiduously during January and February, "... seeing it last on 17 Feb, as a small nebulous speck ..." (Biggs 1881c). A year and a half later he forwarded his positional observations of this object to John Tebbutt.

The next comet to attract his attention was the Great Comet of 1881, which was one of the three comets independently discovered by John Tebbutt during his lifetime (see Orchiston 1981). Included with a letter Biggs wrote Tebbutt on 27 June 1881 were his positional measurements, obtained once again directly from the setting circles (Biggs 1881b). He thought these may be of use to Tebbutt when calculating the orbit, but as it turned out the positions were too imprecise and could not be used. To rectify the situation, Tebbutt recommended that Biggs resort to micrometric measurements.

Biggs had his first chance to try his hand at micrometric cometry astronomy in September 1881, with the appearance of Schaeberle's Comet (which, incidentally, Tebbutt also independently discovered — see Tebbutt 1908:53). But although he obtained many positions of this object using the circles during September and October (Biggs 1881c, 1881d), it proved too faint in the 76 mm telescope to permit micrometric determinations. As some small measure of compensation, however, he was able to send Tebbutt a number of field drawings of the object (Biggs 1881c).

But if Biggs's initial attempts at micrometric observations were frustrated, all was to change in 1882 with the advent of Comet Wells. Moreover, he had the use of his new, home-made, bar micrometer. During June and July he obtained a large number of observations of this comet on 18 different nights (Biggs 1882e, 1882f, 1882g), recording on each occasion:

> mean time
> right ascension (from the circles)
> declination (also from the circles)
> position angle of the tail
> length of the tail
> general comments.

On 8 nights he also managed to obtain micrometric positions, but had no way of identifying the reference stars used, leaving this onerous task to Tebbutt.

Later in the year Biggs had further opportunities to enhance his cometary observational prowess, with the arrival of the Great Comet of 1882. But, being an early morning object, it discriminated against working men like Biggs, and the morning fogs prevalent in Launceston also made it an elusive object. Nevertheless, Biggs succeeded in obtaining more than 25 observations of the comet between 7 October 1882 and 7 April 1883, some of them with the micrometer (Biggs 1882i, 1882j, 1883a, 1883b, 1883c). He also prepared drawings of the comet, paying particular attention to the nucleus and the tail. In addition, on 15 January 1883 he observed the occultation of a ninth magnitude star by the comet's nucleus, which "I flatter myself ... is of very considerable scientific importance." (Biggs 1883a). Biggs forwarded all his observations to Tebbutt, but was so concerned about their usefulness that on 6 November 1882 he wrote:

> I would like to say that if these notes are of no value, and as such are not worth the trouble of sending or receiving, I should be glad if you would tell me so.

He seemed to derive very little assurance from Tebbutt, as also in the case of the 15 January event mentioned above, and it is perhaps partly as a result of this that he did not proceed immediately to academic publication (although his observations warranted a permanent place in the *Astronomische Nachrichten* or *Monthly Notices of the Royal Astronomical Society*). What Biggs did, instead, was to prepare an account of his work for the local newspapers, thereby initiating a practice that he was to pursue avidly throughout his astronomical lifetime.

The 1880s were important years in cometary astronomy in that they brought a comparatively large number of Australian discoveries (see Orchiston and Bhathal n.d.). We have already noted Tebbutt's Comet of 1881. December 1883, meanwhile, marked the discovery of a new Australian comet by the Tasmanian duo, Clevers and Thirlwall (Orchiston 1983a). Neither was an astronomer, and despite its brilliance, this naked eye object escaped the attention of astronomers, appearing as it did during the "Silly Season". Biggs not only failed to sight this comet, but even went so far as to doubt its very existence. He made no cometary observations in 1883, other than of the Great Comet of 1882.

Australia again contributed a comet in 1884, through Ross of Melbourne, and throughout January both this object and Pons's periodic comet graced southern skies. Biggs succeeded in observing both objects, but Comet Ross only sparingly, as it was "... a very hazy, ill-defined object." (Biggs (1884c). Comet Pons featured more prominently, and in addition to his standard visual observations, our innovative Mr. Biggs also subjected it to spectroscopic analysis, using a small direct vision spectroscope by Browning. Indeed, he went further, and prepared a short paper on this work for the Royal Society of Tasmania (see Biggs 1884e). In it he reported the presence of three emission bands which he was able to associate with the comet nucleus. He also emphasized that it was up to others to interpret his observations and results.

As was his usual practice, Biggs forwarded his visual observations of both Comets Ross and Pons to Tebbutt (Biggs 1884a, 1884b, 1884c, 1884d; Tebbutt 1885), and again queried their value (Biggs 1884c). We must assume that Tebbutt's response was positive, for the observations appeared later in the year in a short paper in *Monthly Notices*. These 1884 papers were Biggs's first scientific (as opposed to popular) astronomical publications. The latter paper simply presented a list of micrometric positions, running from Januaury 26 to April 4. There was no attempt to compute the orbital elements; nor were any descriptions of the two comets given.

In contrast to 1884, the following year was a lean one, with no cometary observations. However, during the first half of the year Biggs did search unsuccessfully for Comet Barnard, only to learn later that its magnitude was far beyond the reach of his little refractor (Biggs 1885b). By the time the large reflector arrived, the comet had moved on.

The year 1886 turned out to be significant, with three different comets (Barnard, Brooks and Fabry) all within the grasp of Biggs's enriched telescopic range. Towards the middle of the year, all three were visible at the same time. On July 21 Biggs (1886c) sent Tebbutt a number of micrometric positions, but he did not feel that any of these observations warranted writing up for his astronomical colleagues.

This was not the case in 1887 when the start of the year brought with it a major comet. This turned out to be a particularly interesting object, from two points of view. In the first place, its head was apparently devoid of any obvious nucleus, and secondly, its orbit mirrored that of the Great Comet of 1880 (which was also of a headless nature). Biggs noted both of these anomalies, and in addition to raising them in his letters to Tebbutt (Biggs 1887b, 1887c), he reported on them in the local newspapers, and in a research paper published by the Royal Society of Tasmania (Biggs 1887a). He was of the opinion that this remarkable object "... is not a Comet at all, but possibly a meteoric stream." (Biggs 1887b; his underlining). His published account of this "comet" is a short but interesting one.

Three different comets within the range of the 216 mm telescope were visible in southern skies during 1888, but only the first of these, discovered by Sawerthal at the Cape Observatory, was observed by Biggs. He obtained a number of micrometric observations, between 24 February and 6 April, and in addition to forwarding these to Tebbutt (Biggs 1888a, 1888b), and reporting them in the local newspapers, sent off two short papers to *Monthly Notices* (Biggs 1888c, 1888d). The first of these also included magnitude estimates of the comet and details of the appearance of the head. Thanks to his newly-acquired filar

micrometer, Biggs (1888b) felt particularly happy with the positional measurements, and congratulated himself on their presumed accuracy!

Australia laid claim to yet another comet discovery in 1889, thanks to the efforts of Mr. J. E. Davidson of Queensland, and this was the only comet followed by Biggs that year. His observations spanned the period 26 July-27 August, and were sent to Tebbutt (Biggs 1889a) and written up in the local newspapers. He also prepared a very short descriptive paper for the Royal Society of Tasmania (Biggs 1889c).

Comet Davidson was the last comet observed by Biggs until late 1892, despite the fact that at least three objects were within the range of his 216 mm instrument during the intervening period. The fact of the matter is that Biggs's health failed (Biggs 1890). In a letter dated 11 November 1891, he explains the situation to Tebbutt:

> You may judge that it means badly for a lover of science when, having a spare evening, and thinking, "I ought to be at work", he looks out, and feels much relieved to find there is no sky. Yet such has been my experience largely of late . . . I feel that I have not now or for some time past either the strength or the spirit for astronomical work. From these causes I have been compelled to let all the Comets go by without having ever seen them. (Biggs 1891a; his underlining).

Biggs resumed his comet-observing on 24 November 1892 when he obtained positional measurements for the "Andromeda Comet", but he was unable to find it two nights later, or on the 28th (Biggs 1893a). Shortly afterwards he was successful in locating Comet Brooks 1892 and also obtained a single micrometric position for it.

These positional measurements of November and December 1892 were the last cometary observations undertaken by Alfred Barrett Biggs. During the thirteen year period 1880-1892 he observed fifteen different comets in nine different years (see Tables 1 and 2), and prepared numerous newspaper articles and six short journal articles on this work. The focus throughout was astrometry, although he did record and report on the nature of the head and tail of a number of comets. However, apart from his brief comparative foray when confronted by the "headless" comet of 1887, he made no attempt to develop his work at an analytical level. Nor did he ever publish any orbital elements — indeed, he at one time admitted to Tebbutt that the computations were beyond him (Biggs 1882a). Biggs simply saw his papers as sources of raw data for others, who were welcome to use the data in whatever ways they saw fit.

There is one final aspect of Biggs's cometary work that deserves our attention and that is his comet-searching activities, which he commenced with a vengeance in 1882 when Tebbutt tried to form the Australian Corps of Amateur Comet-seekers (see Orchiston 1982a). Biggs ended up as one of only two active members of the abortive Comet Corps (the other being Tebbutt), and was assigned the zone from 40° to 60° south declination. At first he lacked adequate star charts and lists of nebulae and clusters that could easily be mistaken for faint comets (Biggs 1882c), but Tebutt soon rectified these shortcomings (Biggs 1882f, 1882h, 1882j).

Biggs began his quest for new comets on 8 June, and carried out regular searches in his sky zone during that month and in July and August, before cloudy skies and pressure of work took their toll. Observations of Comet Wells cut into time available for comet-searching, and with the arrival of the Great Comet of 1882 this became even more of a problem. There was also an added distraction: preparations for the 6 December Transit of Venus.

Although Biggs did re-activate his comet-sweep programme in early November (Biggs 1882j), an event occurred soon after which dampened his spirits once and for all: the American astronomer, Barnard, quite by accident discovered a new comet within Biggs's allocated sky zone. Naturally, Biggs was devastated. "There seems to [be] a fatality against my prosecution of the work I have undertaken" he lamented to Tebbutt on 2 December 1882. This unhappy event put paid to any ambition Biggs ever had to carry out further systematic

Table 1
Outline of annual telescopic observations by A. B. Biggs, 1878-1892

TYPE OF OBSERVATION	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892
Comets			x	x	x		x		x	x	x	x			x
Double Stars	x	x	x		x	x		x	x	x	x				
Transit, Mercury				x										x	
Transit, Venus					x										
Lunar Eclipse								x						x	

Table 2
Comets observed by A. B. Biggs, 1880-1892

YEAR	NUMBER	NAME(S)
1880	1	"Great"
1881	2	"Great" (Tebbutt); Schaeberle
1882	2	Wells; "Great"
1883	0	
1884	2	Pons; Ross
1885	0	
1886	3	Barnard; Brooks; Fabry
1887	1	"Great"
1888	1	Sawerthal
1889	1	Davidson
1890	0	
1891	0	
1892	2	"Andromeda"; Brooks

comet-searching, and although he occasionally made *ad hoc* searches through into 1885 (Biggs 1883c, 1885b), the original programme was never re-activated. Tebbutt, meanwhile, officially announced abandonment of the project in 1883.

Double Stars

After comets, double stars were Biggs's major love, and he began a long affair with them in May 1878 (Biggs 1882a), using his home-made reticle micrometer and the 76 mm telescope. However, he was faithful throughout to just one star, alpha Centauri. On 14 March 1882 he forwarded a plot of his 1878-1882 observations to Tebbutt with the comment that

> . . . I cannot see yet how to project an orbit out of these positions, but it seems to me perfectly evident that the period assigned to this star — 76¼ years is vastly overestimated. I should think 50 years would be much nearer.

Tebbutt was asked to comment, and immediately did so by pointing out that all the measurements were in error. In other words, the reticle micrometer was faulty, and it was this revelation that prompted Biggs to manufacture a new one — this time a reliable bar micrometer (see Biggs 1887d:80).

In the interim, though, Biggs (1882b) prepared a manuscript on alpha Centauri, and included in it a plot of position angle and distance, derived from observations by a number of different observers (including Tebbutt and himself). This, too, went to Tebbutt for comment, and underwent substantial modification before it eventually emerged in published form five years later (Biggs 1887d). The paper came complete with a set of new reliable observations by Biggs, and measurements by Lacaille, Herschel, Maclear, Jacobs, Powell, Ellery, Suliger and Tebbutt. Biggs was able to show that the pre-1831 observations were all in error (as were his own early ones), and from the reliable readings available was able to calculate the orbital elements and a period of 83.7 years. He also computed the mean separation of the components as 20.043 AU.

This interesting paper, undoubtedly Biggs's best, and his sole assault on mathematical astronomy, owes much to Biggs's friend and mentor, John Tebbutt. It was Tebbutt who provided him with the measurements of the other observers, and it was Tebbutt who introduced an unsure Biggs to the intricacies of orbital computations and guided him safely through the calculations. The paper could, by rights, have been co-authored.

Two years later, Biggs (1889d) published a second paper on alpha Centauri, with a long series of observations from 19 March to 21 November 1888. But this paper was prepared as much to illustrate the efficiency of the home-made bar micrometer (when compared with the new filar micrometer) as to place the measurements on permanent record.

It is not clear when, or how often, Biggs carried out double star observations after 1888. His only reference to the topic, in a letter to Tebbutt (Biggs 1893c), mentions a planned paper using a long series of measurements extending over many years, but this never eventuated.

In summary, then, Biggs's double star work revolved around just one object, alpha Centauri, and spanned more than twelve years (see Table 1). Two scientific papers were published on this work, which was assisted — almost supervised — throughout by John Tebbutt. Biggs's dream of expanding his program beyond alpha Centauri, and doing " . . . useful work amongst the Southern Dbles . . ." (Biggs 1882d), never materialized despite the instrumental means (and, presumably, the opportunity).

Eclipses and Transits

Biggs, as we have seen, virtually began his observational "career" as an astronomer with the 1874 Transit of Venus, but at that time served very much in a subordinate capacity. It is fortunate that the next twenty years were to offer him one more Transit of Venus and three Transits of Mercury, most of which he paid diligent attention to.

The first of these interesting and comparatively important phenomena was a Transit of Mercury in 1878, which he did not observe, but he attempted to make amends with the 8 November 1881 Transit of Mercury:

> I had been making preparations for a careful observation days before, and for time, had a good chronometer which I had, the evening before, checked by star transit both N-wards and S-wards. (Biggs 1881g; his underlining).

Biggs missed the ingress phase owing to clouds, and made the 0.8 km trip back to the Bank where clear skies revealed the Transit in progress via his little 51 mm telescope. He was very aware of a "halo" around the planet (Biggs 1881f). Fate again played its cruel hand during the egress phase:

> . . . as the time for the egress drew near, the sky being then pretty clear, I went again to the Observatory. By the time I got there, clouds were gathering up; and just as I got the Sun into the telescope, clouds obliterated it from view, and I saw no more of it. I could only "gnash my teeth". (Biggs 1881g).

One year later brought the 1882 Transit of Venus, and Biggs determined to be ready for this. In letters to Tebbutt dated 13 September, 6 November and 2 December 1882 he discusses his observational strategy, queries the value of observations with a mere 76 mm telescope, and finally decides to focus on the contacts. Because the Transit was not going to be visible from his observatory, Biggs decided to set up a temporary station on the Reverend Canon Brownrigg's property. Brownrigg, well known for his missionary work in Bass Strait (see Murray-Smith 1979), at that time owned ". . . a very nice little Observatory . . ." and Biggs (1882k, 1882m) spent a good deal of time during November and early December renovating the old transit instrument housed there, so that they would have access to an accurate time service. All this effort paid off when the day dawned clear and the Transit was successfully observed. Regrettably, Biggs's report on it for the local newspapers did not find its way into an academic journal, even though it conveyed ". . . all the information we have to offer learned societies". (Biggs 1882m).

Biggs was provided with a second chance to observe a Transit of Mercury on 10 May 1891, and this time had better luck than ten years earlier. His brief report, published by the Royal Society of Tasmania (Biggs 1891d), includes a number of timings and micrometric measurements, and mention of a bright spot observed on the disk of the planet. Soon after the formation of the New South Wales Branch of the British Astronomical Association (see Orchiston and Bhathal 1984), a paper by Biggs on this Transit was presented (*in absentia*) at one of the meetings (BAA 1895-1896:416).

During the period 1878-1893, Biggs also observed two lunar eclipses, the first in March 1885 with the 76 mm telescope and the second in May 1891 with the large reflector. Short, descriptive papers were written on both events (Biggs 1885a, 1891c). Finally, Biggs (1893a) observed at least one total solar eclipse, and although he wrote a paper on it, this was not published by the journal in question.

Other Observations

In the absence of Biggs's observing diaries we cannot reconstruct the full spectrum of objects or occasional phenomena that he observed. However, his letters to Tebbutt reveal that from time to time he recorded aurorae and sunspots (Biggs 1882b, 1886b) and observed the variable star R Carina (Biggs 1882b). However, no publications, based on these observations, resulted.

During 1886, in addition to comets and double stars, Jupiter attracted attention. On 16 April he used the large reflector with a magnification of 200X to observe a lunar occultation of the planet. His means of obtaining accurate time are outlined in the published account:

> . . . my clock is with my smaller telescope in the adjoining grounds (Mr. Pullen's garden). I got the time from it to the large telescope by an electric line communicating

> motion each minute to the hands of the dial, and the clock beats (seconds) I got by telephone. (Biggs 1886d:32).

This clearly demonstrates Biggs's mechanical ingenuity. During the occultation, he carefully studied the relative luminosity of the Moon and Jupiter, and concluded that "... the brightness of the planet was out of all proportion to the relative amount of light received by him from the sun." (*ibid.*).

The possibility that Jupiter might be partially self-luminous then suggested itself to Biggs, and he addressed himself to this topic shortly afterwards (on 28 June) during a conjunction of Mars and Jupiter. He made comparative measurements of the surface brightness of the two bodies, and obtained what he thought to be confirmatory results (Biggs 1886c). The upshot of the various Jupiter observations was a paper titled "Is Jupiter self-luminous?", which appeared in the *Papers and Proceedings of the Royal Society of Tasmania* (Biggs 1886a). This paper presents, "... with some diffidence ...", an affirmative case, in line with the views then held on the matter by such notables as Newcomb and Proctor. Towards the end of what is basically an interesting, if somewhat simplistic, analysis Biggs (1886a:36) concludes as follows: " I must say that the result of my measures appears incredible even to myself."

The only other astronomical observation of note for which we have a record is the 1890 opposition of Mars, which Biggs (1890) reported on in the local newspapers. His 39 micrometric positions spanned the period 18 May-2 June.

Finally, in early 1893 Tebbutt suggested that Biggs observe phenomena of Saturn's satellites, but Biggs was somewhat diffident:

> I much doubt whether my telescope, or my skill is sufficient to do work of much value ... However, I will try what I can do as I have opportunity ... (Biggs 1893b; c.f. Biggs 1893c).

Despite these good intentions, it would appear that Biggs never did initiate this programme. Failing eyesight and declining health were important factors.

Like most serious amateur astronomers who operated *de facto* "city observatories", Biggs also maintained a meteorological service, in collaboration with Reverend Brownrigg. They operated a set of instruments forwarded by Captain Shortt of the Hobart Observatory, and reported their results monthly in the *Launceston Examiner* (B. Underwood, *pers. comm.*, January 1984).

Biggs also paid particular attention to the mysterious post-sunset "sky glows" that were prominent in late 1883 and throughout 1884. These are now known to be associated with the eruption of Krakatoa in Indonesia, but at that time caused great controversy. They also rendered comet-searching a non-event for a little while (Biggs 1884a).

Biggs (1884c) made a protracted spectroscopic study of the "sky glows" with the 76 mm telescope, and published a short paper on his work (Biggs 1884g). In this matter, he "... dare not venture to offer an opinion ...", merely leaving his observations for others to interpret, but in a much later letter to Tebbutt stated that he was convinced they were connected with volcanic activity (Biggs 1890). He also saw a connection between these "sky glows" and earthquake activity, and by this time was referring to them as "seismic twilights". This was an interesting deduction, drawing as it did on two different scientific disciplines, but Biggs was well qualified to do so, as the founder of instrumental seismology in Australia and one of the pioneers (see Royal Society of Tasmania 1984).

Another service often offered by amateur "city observatories" was a local time service, and although we know that Biggs maintained accurate time for his own purposes, whether or not this was also available to the citizens of Launceston cannot be established. One service he did perform, though, was to provide a revised determination of the latitude and longitude for the city. Consequently, we find the 1888 edition of *Walch's Tasmanian Almanac* listing new co-ordinates for Biggs's Observatory (see page 265), ones that correspond to the values

given on the monument now in Royal Park. Underwood (*pers. comm.*, January 1984) has recently queried the correctness of the latitude value.

DISCUSSION

Biggs is an enigma. He came to astronomy late in life, when other men were finetuning or abandoning their hobbies, and his contribution lasted a comparatively short time. Although his observations spanned the period 1878-1892, or perhaps longer, when we refer to Table 1 we see that the bulk of his work was accomplished during the 1880s.

By 1890 he was 64 years of age, and failing health, partly caused by over-exertion at the Bank, began to take their toll. It is not surprising that he was forced to scale down his observatory work, particularly when his eyesight began to deteriorate. He was also disillusioned when some of his research papers were not accepted for publication. On 30 January 1893 he wrote Tebbutt as follows:

> I confess to a feeling of disencouragement with regard to astronomical work . . . I have sent home [research papers, from time to time], generally to the Editors of the Observatory — Eng Mech^{c}, or Secretaries of the R.A.Soc^{y}; and sometimes they have been taken notice of. But notes that I have forwarded not long since, I have never heard of again: e.g. the late total solar eclipse; transit of Mercury, Comet observations &c. I can only assume that my notes are worthless, and therefore I am wasting my time and energy . . . (His underlining).

By 1897 the 0.8 km walk to the observatories from the Bank was almost beyond him, and Biggs (1897) reluctantly announced; "I regret much that I have been compelled to almost lay aside my Observatory work, of late. I find advancing years telling . . .". His departure from scientific astronomy was clearly forced on him and was not something surrendered to meekly in the light of a shift of interests.

When Table 1 is examined again, it is interesting to note Biggs's preoccupation with comets and the double star (as it was then known) alpha Centauri, and his dismissal of other potential targets popular among contemporary Australian astronomers, amateur and professional (see Orchiston 1982b:237-239, for example). He looked only very occasionally at variable stars, and never — to our knowledge — at lunar occultations of stars, minor planets, or phenomena of Jupiter's satellites. And even that popular quarry, the double star, received far from equable treatment. What, precisely, made Biggs focus almost exclusively on comets and alpha Centauri is not known. His instruments and reference library permitted a more catholic approach, and with Tebbutt's continued assistance and advice he was capable of making a greater contribution. Was it merely a personal preference, enforced perhaps by lack of time and ill health, or did it relate also to his self-appraisal? As we have seen from his correspondence with Tebbutt, Biggs frequently queried his own astronomical abilities and the value of his work (see Biggs 1882a, 1882e, 1882h, 1882j, 1882k, 1883b, 1884c, 1884d, 1886c, 1891a, 1893a, 1893b).

Whatever the reasons for his observational preferences, we must be satisfied with the breadth of observational techniques Biggs employed in his work. In addition to submitting his target objects to visual inspection, he also subjected them to micrometric, and in some cases spectroscopic, analysis. All he lacked was the photographic plate, but that came to most amateur astronomers after the turn of the century. It is only to be regretted that the 216 mm telescope arrived so late in Biggs's astronomical career, and that his declining health prevented its full potential from being realized.

Given Biggs's lowly rating of his own work, why, we may ask, did he attempt publication in scientific journals, and face the humiliation of possible refusal? His answer on this point is quite clear:

> However little my modest efforts may be estimated by the master minds who lead the way, both on this and the other side of the equator . . . there are times when locality

> has an important bearing upon the observations of an astron! event, and I think my situation is almost unique. Under such circumstances, careful observations and notes from even a novice may be of some value. (Biggs 1893a; his underlining).

Biggs felt he could make a useful contribution to scientific astronomy, if only in the form of data presentation, through the circumstances of his geographical location.

But, this explanation merely serves to mask another even more important reason for Biggs's involvement in astronomy, which had nothing to do with the scientific aspect of the discipline. It related to the concept of popular astronomy, and a fostering of public interest in the science. This was why Biggs made such a point of writing up his observations for the local (Tasmanian) newspapers, and his attitude in this regard clearly emerges in the following quote (taken from a letter to Tebbutt):

> . . . I have sent you from time to time some of my humble literary efforts on various subjects. I should be ashamed to produce such in any of the great scientific centres; but in our little colony, which is so wofully [*sic.*] backward in the subjects I have discussed, these efforts are somewhat appreciated. (Biggs 1891a).

Biggs contributed to popular astronomy, not just through his newspaper reports, but via various lectures he delivered, and by opening his observatories to the Tasmanian public. His Depot Ground observatory served virtually as a "city observatory" for the metropolis of Launceston (Tasmania's second largest city), and to some of its citizens Biggs was affectionately referred to as the "Astronomer Royal" (Scott and Scott 1935). It is apparent (see Orchiston 1984a, 1984b) that Biggs's major contribution to Australian and Tasmanian astronomy was in the public arena, and not in scientific astronomy.

It remains for us to examine two other aspects of Biggs's astronomical activities — his relationship with and dependence upon the New South Wales astronomer, John Tebbutt, and his place in Tasmanian astronomy. By the time that Biggs struck up their friendship in 1881, Tebbutt had already achieved international prominence, and was regarded in most overseas circles as Australia's leading astronomer. Certainly he stood hands and shoulders above all other contenders on the basis of his extraordinarily ambitious range of observational programmes and his publications record. He was a powerful ally to have, and in addition to strengthening Biggs's library, gave freely of his advice. All this assistance proved somewhat of an embarrassment to Biggs, who was slightly overawed that he should come in for such favoured treatment by so renowned an individual. He was also concerned that the relationship was very much a one-way affair:

> Your letters are always most welcome to me, and I feel under great obligation to you for the assistance I receive from you in this way. The advantage is, I am sorry to say, all on my side. (Biggs 1885b; c.f. Biggs 1881f, 1882f).

Throughout their friendship, Tebbutt offered advice on observational programmes, observing techniques, and instrumentation (including many critical comments on the Mark I micrometer, which Biggs greatly resented — see Biggs 1882e, 1882g). He provided Biggs with those basic reference works essential to any serious observational astronomer; encouraged him to publish in scientific journals, helping him with reference material, and even refereeing his papers (as in the case of the first one on alpha Centauri); and steered him through the difficult world of mathematical astronomy. They exchanged photographs (Biggs 1884a), and reprints or copies of their papers.

During their relationship, Biggs was remarkably flexible for a man getting on in years. He was always willing — indeed eager — to learn, and would have welcomed the opportunity for even closer tuition. In 1888 we find him writing Tebbutt as follows:

> I often wish it were possible for me to spend a year or two with you as pupil assistant. There is so much I want to learn that you can teach me. (Biggs 1888b).

This never came to pass. Indeed, the two men never met, except through their letters, and even these declined in number as the years passed by (see Table 3).

Despite his protestations, the relationship was not quite as one-sided as Biggs imagined. Prior to his foray into the academic publications field, Biggs sent Tebbutt all his observations, for the exclusive use of the latter, and when Tebbutt sought to establish the Australian Comet Corps in 1882 Biggs was not only the principal participant but also the one who perfected the telegraphic code to be employed in the event of a comet discovery (Biggs 1882f, 1882g). Biggs also supplied Tebbutt with the names of other Tasmanians who could be approached in connection with the Comet Corps, together with details of their instruments, and personally approached some of these on Tebbutt's behalf (see Biggs 1882c).

Table 3: Letters from A. B. Biggs To J. Tebbutt, 1881-1897

YEAR*	NUMBER
1881	7
1882	14
1883	4
1884	5
1885	2
1886	2
1887	2
1888	2
1889	0
1890	1
1891	1
1892	0
1893	3
1894	0
1895	0
1896	0
1897	1
TOTAL:	42

* Biggs's first letter to Tebbutt was written in 1881, and his last in 1897.

Just what, we may ask, is Biggs's rightful place in Tasmanian astronomy? In a State which, during the nineteenth century, made only a token commitment to professional astronomy (see Baracchi 1914:350; The Encylopedia . . . n.d.:108-109), his contribution stands out as important, though easily eclipsed by the achievements of Francis Abbott of Hobart. Abbott (Baracchi 1914:354; Rimmer 1969) was actively engaged in astronomy, meteorology and maintaining a time service from 1855 to 1880, using two refracting telescopes, one of 115 mm aperture and the other in the 140-150 mm range (see Russell 1872). He also had access to a transit instrument, a spectroscope and a micrometer. Over the years he published a large number of research papers on comets, variable stars, and current phenomena in Australian and overseas journals. He also produced several monographs reporting his meteorological observations. In 1865 he independently discovered a comet. After Tebbutt, Francis Abbott would have to rate as Australia's greatest nineteenth century amateur astronomer, and hemust obviously take top Tasmanian ranking. Biggs, however, comes an easy second. Indeed, Baracchi (1914) and McAulay (1902) felt that Abbott and Biggs were the only two individuals worthy of mention, who attained any degree of professionalism. But while Abbott — like Tebbutt — was a respected international figure, Biggs's reputation lay more at the local level. Even in the national arena, he was merely one of a number of competent but by no means brilliant amateurs. To the citizens of Launceston, however, he reigned supreme as their very own "Astronomer Royal".

In this assessment, Biggs the astronomer is purposely separated from Biggs the man. Although Biggs (1883d) rated astronomy as his favourite hobby, he was also very actively involved in seismology (as we have seen) and microscopy, and the mechanical and optical ingenuity he brought to astronomy was directed in similar fashion to these disciplines. His mechanical skills were also applied to the construction of telephones, a microphone and an electric master clock (Obituary 1900). In addition to these practical projects, he also reflected and wrote on the limitations of the refracting telescope (Biggs 1891b; see, also, BAA 1896-1897: 12).

For many years Biggs was an active member of the Launceston Mechanics Institute, serving three successive sessions as President from 1893 and three years (1898-1900) as Treasurer (Whitfield n.d.:23-24). He was elected to the Royal Society of Tasmania (not London, as some of his descendants believe) about 1885, and joined the New South Wales Branch of the British Astronomical Association in 1895 (BAA 1894-1895).

In the non-scientific area, Biggs

> . . . was strongly devoted to . . . music, and held the conductorship of various choirs with signal success from the age of 14 until he resigned the charge of St. Andrew's, Launceston, in 1893. He was a composer of no mean merit, chiefly choral, and the musical world has been decidedly enriched by his hymns and anthems. (Obituary 1900).

He was also greatly concerned about community and political issues, and for many years contributed frequently to the press, his letters to the Editor ". . . being read with interest throughout the island and elsewhere." (*ibid.*).

CONCLUSION

After Francis Abbott, Alfred Barrett Biggs was Tasmania's most important nineteenth century astronomer, amateur or professional. He was born in 1825 and only came to astronomy comparatively late in life, largely due to the influence of his friend and fellow amateur astronomer, Dr. William Valentine of Campbell Town, and the 1874 Transit of Venus. His contribution to astronomical research lasted a mere fifteen years, and in this time he observed and wrote on a range of current phenomena, but his favourite targets were comets and the double star alpha Centauri. He also devoted some time to comet-searching. He published sixteen papers on astronomical matters in the *Monthly Notices of the Royal Astronomical Society* and the *Papers and Proceedings of the Royal Society of Tasmania*.

Biggs brought to Tasmanian astronomy a great deal of dedication and enthusiasm and a good measure of mechanical and optical genius, and these attributes were turned to good account in refining his principal instruments, a 76 mm refractor and 216 mm reflector, housed in separate but adjacent observatories. Much of his observational work was in positional astronomy, accomplished with micrometers of his own design and construction, though he eventually acquired a professionally-made filar micrometer for use with the larger telescope. After his death the various instruments and appliances were dispersed, and in most cases their current whereabouts is unknown.

Despite his considerable talents, Biggs constantly queried the value of his scientific work, and it was only through the support and close friendship of John Tebbutt, Australia's most famous nineteenth century astronomer, that he continued. Tebbutt also contributed to Biggs's library, and helped steer him through the intricacies of mathematical astronomy. Thanks to Tebbutt's support, Biggs found the academic isolation caused by his geographical situation tolerable.

But not all of Biggs's efforts were directed towards scientific astronomy. He was also devoted to the concept of popular astronomy, and enthusiastically pursued this through lecturing, writing for the Tasmanian newspapers and operating one of his observatories as a *de facto* "city observatory". To the townsfolk of Launceston he was affectionately known as

the "Astronomer Royal", and it was in the area of popular astronomy, as opposed to scientific astronomy, that Biggs made his greatest contribution to Australian and Tasmanian astronomy.

Although Biggs rated astronomy his principal hobby, he had many other interests and is also well known for his pioneering work in instrumental seismology. Alfred Barrett Biggs belongs to that rare breed, the amateur multi-disciplinary scientist, now virtually extinct in the specialist world of the 1980s. He is very much a part of Australia's scientific heritage.

ACKNOWLEDGEMENTS

This project would not have been possible without the help of many people, and I am particularly indebted to:

Reverend H. G. Biggs (Hobart); Mr. R. A. Biggs (Hobart); Ms. Gwen Brown (Melbourne); Mr. Alex Buchanan (Hobart); Mrs. S. M. Dent (Northern Regional Library, Launceston); Ms. Rona Gardner (Queen Victoria Museum, Launceston); Ms. S. Gibbs (National Archives and Record Service, Washington); Mr. Don Gregg (Tasmanian Museum, and Art Gallery, Hobart); Ms. Rhonda Hamilton (Queen Victoria Museum); Mr. B. M. Harris (Perth); Mr. D. Hodgkinson (Launceston); Miss P. M. King (University of Tasmania Library); Ms. M. McCrae (Archives Offices of Tasmania); Mitchell Library staff (Sydney); the late G. J. O'Brien (Campbell Town); Professor Donald Osterbrock (University of California, and Lick Observatory); Mr. and Mrs. Doug Sutton (Melbourne); and Dr. Bob Underwood (Hobart).

I am grateful to Reginald A. Biggs for permission to publish Plate 1. Finally, I wish to thank Victoria College and the Donovan Trust for contributing towards the cost of this project.

REFERENCES

The following abbreviation is used:
In TL = Original in *Letters to J. Tebbutt.*
Twenty-two volumes (1881-1897) in the
Mitchell Library, Sydney (A3687-A3708).

Ashbrook, J., 1972. John Tebbutt, his observatory, and a possible nova. *Sky and Telescope* 44(4):236,240.

BAA, 1894-1895. List of new members. *Journal of the British Astronomical Association* 5(7):373-374.

BAA, 1895-1896. Reports. New South Wales (Sydney). *Journal of the British Astronomical Association* 6(9):416-422.

BAA, 1896-1897. Reports. New South Wales (Sydney). *Journal of the British Astronomical Association* 7(1):11-13.

Baracchi, P., 1914. Astronomy and geodesy in Australia. In *Federal Handbook Prepared in Connection with the Eighty-Fourth Meeting of the British Association for the Advancement of Science Held in Australia, August, 1914.* Melbourne, Government Printer. Pp. 326-390.

Beever, A. E., 1972. *Launceston Bank for Savings, 1835-1970. The History of Australia's Oldest Savings Bank.* Melbourne, Melbourne University Press.

Biggs, A., 1834. Letter to his mother, dated 19 May. In Brown Collection.

Biggs, A., 1835. Letter to W. Biggs, dated 30 October. In Brown Collection.

Biggs, A., 1837. Letter to W. Biggs, dated 3 April. In Brown Collection.

Biggs, A., 1838. Letter to father and mother, dated 24 August. In Brown Collection.

Biggs, A. B., 1848. Letter to "Relations", dated 24 November. In Brown Collection.

Biggs, A. B., 1863. Letter to S. Stephens, dated 28 December. In Archives Office of Tasmania:ED2/1/24.

Biggs, A. B., 1868a. Description of a method of microscopic measurement. MS in University of Tasmania Archives.

Biggs, A. B., 1868b. Letter to Royal Society of Tasmania, dated 1 June. In University of Tasmania Archives.

Biggs, A. B., 1881a. Letter to J. Tebbutt, dated 27 June. In TL.

Biggs, A. B., 1881b. Letter to J. Tebbutt, dated 25 July. In TL.

Biggs, A. B., 1881c. Letter to J. Tebbutt, dated 29 September. In TL.

Biggs, A. B., 1881d. Letter to J. Tebbutt, dated 14 October. In TL.

Biggs, A. B., 1881e. Letter to J. Tebbutt, dated 19 October. In TL.

Biggs, A. B., 1881f. Letter to J. Tebbutt, dated 17 November. In TL.

Biggs, A. B., 1881g. Letter to J. Tebbutt, dated 23 November. In TL.

Biggs, A. B., 1882a. Letter to J. Tebbutt, dated 14 March. In TL.

Biggs, A. B., 1882b. Letter to J. Tebbutt, dated 21 April. In TL.

Biggs, A. B., 1882c. Letter to J. Tebbutt, dated 13 May. In TL.

Biggs, A. B., 1882d. Letter to J. Tebbutt, dated 2 June. In TL.

Biggs, A. B., 1882e. Letter to J. Tebbutt, dated 22 June. In TL.

Biggs, A. B., 1882f. Letter to J. Tebbutt, dated 28 June. In TL.

Biggs, A. B., 1882g. Letter to J. Tebbutt, dated 22 July. In TL.

Biggs, A. B., 1882h. Letter to J. Tebbutt, dated 13 September. In TL.

Biggs, A. B., 1882i. Letter to J. Tebbutt, dated 14 October. In TL.

Biggs, A. B., 1882j. Letter to J. Tebbutt, dated 6 November. In TL.

Biggs, A. B., 1882k. Letter to J. Tebbutt, dated 2 December. In TL.

Biggs, A. B., 1882m. Letter to J. Tebbutt, dated 12 December. In TL.

Biggs, A. B., 1883a. Letter to J. Tebbutt, dated 16 January. In TL.

Biggs, A. B., 1883b. Letter to J. Tebbutt, dated 16 March. In TL.

Biggs, A. B., 1883c. Letter to J. Tebbutt, dated 27 September. In TL.

Biggs, A. B., 1883d. Letter to J. Tebbutt, dated 18 December. In TL.

Biggs, A. B., 1884a. Letter to J. Tebbutt, dated 16 January. In TL.

Biggs, A. B., 1884b. Letter to J. Tebbutt, dated 19 March. In TL.
Biggs, A. B., 1884c. Letter to J. Tebbutt, dated 22 May. In TL.
Biggs, A. B., 1884d. Letter to J. Tebbutt, dated 9 June. In TL.
Biggs, A. B., 1884e. Notes on spectroscopic observations of Comet "Pons" . . . *Papers and Proceedings of the Royal Society of Tasmania*:200-201.
Biggs, A. B., 1884f. Observations of Comets Pons-Brooks and Ross. *Monthly Notices of the Royal Astronomical Society* 45(2):116-117.
Biggs, A. B., 1884g. Report of spectroscopic observation of the twilight glows of February and March, 1884. *Papers and Proceedings of the Royal Society of Tasmania*:202-203.
Biggs, A. B., 1885a. Eclipse of March 30-31, 1885. *Papers and Proceedings of the Royal Society of Tasmania*:309.
Biggs, A. B., 1885b. Letter to J. Tebbutt, dated 31 July. In TL.
Biggs, A. B., 1885c. Letter to J. Tebbutt, dated 26 September. In TL.
Biggs, A. B., 1886a. Is Jupiter self-luminous? *Papers and Proceedings of the Royal Society of Tasmania*:33-38.
Biggs, A. B., 1886b. Letter to J. Tebbutt, dated 9 January. In TL.
Biggs, A. B., 1886c. Letter to J. Tebbutt, dated 21 July. In TL.
Biggs, A. B., 1886d. The occultation of Jupiter. *Papers and Proceedings of the Royal Society of Tasmania*:31-33.
Biggs, A. B., 1887a. The comets of February, 1880, and January, 1887. *Papers and Proceedings of the Royal Society of Tasmania*:38-39.
Biggs, A. B., 1887b. Letter to J. Tebbutt, dated 14 February. In TL.
Biggs, A. B., 1887c. Letter to J. Tebbutt, dated 4 April. In TL.
Biggs, A. B., 1887d. α Centauri, with a graphic projection of its orbit from its apparent curve. *Papers and Proceedings of the Royal Society of Tasmania*:79-82.
Biggs, A. B., 1888a. Letter to J. Tebbutt, dated 24 March. In TL.
Biggs, A. B., 1888b. Letter to J. Tebbutt, dated 7 April. In TL.
Biggs, A. B., 1888c. Observations of Comet α 1888 (Sawerthal). *Monthly Notices of the Royal Astronomical Society* 48(7):348-349.
Biggs, A. B., 1888d. Observations of Comet α 1888 (Sawerthal). *Monthly Notices of the Royal Astronomical Society* 48(8):376.
Biggs, A. B., 1889a. Account of observations of the comet of July/August. In *Letters to J. Tebbutt 1889*.
Biggs, A. B., 1889b. A new dark-field micrometer for double star measurement. *Papers and Proceedings of the Royal Society of Tasmania*:98-101.
Biggs, A. B., 1889c. Observations of the Comet of July and August . . . *Papers and Proceedings of the Royal Society of Tasmania*:105.
Biggs, A. B., 1889d. Recent measures of α Centauri. *Papers and Proceedings of the Royal Society of Tasmania*:106.
Biggs, A. B., 1890. Letter to J. Tebbutt, dated 18 November. In TL.
Biggs, A. B., 1891a. Letter to J. Tebbutt, dated 11 November. In TL.
Biggs, A. B., 1891b. The possibilities of the telescope. *Papers and Proceedings of the Royal Society of Tasmania*:18-24.
Biggs, A. B., 1891c. Total eclipse of the Moon, 24th May, 1891 . . . *Papers and Proceedings of the Royal Society of Tasmania*:44-45.
Biggs, A. B., 1891d. The Transit of Mercury, May 10th, 1891 . . . *Papers and Proceedings of the Royal Society of Tasmania*:46-48.
Biggs, A. B., 1893a. Letter to J. Tebbutt, dated 30 January. In TL.
Biggs, A. B., 1893b. Letter to J. Tebbutt, dated 23 March. In TL.
Biggs, A. B., 1893c. Letter to J. Tebbutt, dated 15 April. In TL.
Biggs, A. B., 1897. Letter to J. Tebbutt, dated 12 June. In TL.
Biggs, A. W., 1901. Letter to the Royal Society of Tasmania. Extract in Society Minutes of 21 February, 1901 (pp. 509-510). In University of Tasmania Archives:RSA/A.5.

Biggs, A. W., 1933. Letter to A. L. Meston, dated 29 September. In University of Tasmania Archives: Meston Papers M.11/1.

Biggs, A. W., n.d. Typescript of interview data (?). In Queen Victoria Museum and Art Gallery: Biggs File.

Biggs Family tree. In Brown Collection.

Ellery, R. L. J., 1901. A brief history of the beginnings of astronomy in Australasia. In *Report of the Eighth Meeting of the Australasian Association for the Advancement of Science*. Melbourne, AAAS. Pp. 1-17.

The Encyclopedia of Tasmania (Illustrated). Hobart, Maitland and Krone. Volume One. n.d.

Expert Sub-Committee, 1978. *Review of Observatories*. Canberra, Australian Government Publishing Service.

Historical Committee of the National Trust of Australia (Tasmania), 1966. *Campbell Town Tasmania. A History and Centenary of Municipal Government*. Campbell Town, Campbell Town Municipal Council.

Kimpton, C., 1980. John Tebbutt — amateur astronomer. In *9th National Australian Convention of Amateur Astronomers*. Geelong, NACAA. Pp. 89-94.

The largest telescope in Tasmania. *The Daily Telegraph*, 19 September, 1885.

McAulay, A., 1902. Practical astronomy in Tasmania, and a proposal for a school thereof. *Papers and Proceedings of the Royal Society of Tasmania*:85-94.

McDonagh, E., and Orchiston, W., 1961. Out Windsor way (life of the astronomer John Tebbutt). *Journal of the North Shore Astronomical Society* 2(1):9-11.

The mathematical mind. *The Examiner* (?1935). Copy in Queen Victoria Museum and Art Gallery: Cuttings Book.

Meston, A. L., 1933. Notes on a memorial to Alfred Barrett Biggs, astronomer. *Papers and Proceedings of the Royal Society of Tasmania*: 26-27.There is also a typescript copy of this paper, containing an additional note by one of Biggs's descendants, in the Mitchell Library:506R.

Murray-Smith, S. (ed.), 1979. *Mission to the Islands. The Missionary Voyages in Bass Strait of Canon Marcus Brownrigg, 1872-1885*. Hobart, Cat & Fiddle.

Obituary A. B. Biggs. *The Examiner*, 20 December 1900 (p. 7).

Orchiston, W., 1968. Biography of a gentleman astronomer: John Tebbutt, F.R.A.S. *British Astronomical Association New South Wales Branch Bulletin* 481:1-2.

Orchiston, W., 1981. Illuminating incidents in Antipodean astronomy: John Tebbutt and the Great Comet of 1881. *Journal of the Astronomical Society of Victoria* 34(6):78-92.

Orchiston, W., 1982a. Illuminating incidents in Antipodean astronomy: John Tebbutt and the abortive Australian association of comet observers. *Journal of the Astronomical Society of Victoria* 35(5):70-83.

Orchiston, W., 1982b. John Tebbutt and the Whakatane Eight Inch Refractor: a review of 'The Australian Connection'. *Southern Stars* 29(8):215-244.

Orchiston, W., 1983a. Illuminating incidents in Antipodean astronomy: the mysterious Tasmanian comet of December 1883. *Proceedings of the Astronomical Society of Australia* 5(2): 282-284.

Orchiston, W., 1983b. Preserving our astronomical heritage: towards a history of astronomy in Australia. In *Supplement to the Proceedings. Tenth National Australian Convention of Amateur Astronomers*. Brisbane, NACAA. Pp. 12.

Orchiston, W., 1984a. Alfred Barrett Biggs and amateur astronomy in Tasmania. In Perdrix, J. L. (ed.). *Eleventh National Australian Convention of Amateur Astronomers*. Perth, Astronomical Society of Western Australia. Pp. 97-110.

Orchiston, W., 1984b. The astronomical activities of Alfred Barrett Biggs of Launceston. In *Earth Tremors. Proceedings of a Seminar commemorating the Centenary of Instrumental Seismology in Australia*. Launceston, Royal Society of Tasmania (Northern Branch). Pp. 11-27.

Orchiston, W., and Bhathal, R., 1984. Illuminating incidents in Antipodean astronomy: attempted formation of the Australian Astronomical Society in 1892. *Proceedings of the Astronomical Society of Australia*, 5(3):422-425.

Orchiston, W., and Bhathal, R., n.d. In the company of comets: an historical survey of cometary astronomy in Australia. Manuscript.

Pawsey, J. L., 1961. Australian radio astronomy. How it developed in this country. *The Australian Scientist* 1(3):181-186.

Plan of Launceston, Tasmania. 1891. Printed map (H. Button, Lithographer) in the Northern Regional Library, Launceston.

Raymond, C. W., n.d. *Transit of Venus. Section VI. Observations Made at Campbell Town . . .* Unpublished Monograph in U.S. National Archives, Washington: Records of the U.S. Naval Observatory, Accession NN366-96, Records of the Transit of Venus (1874). Record Group No. 78.

Rimmer, G., 1969. Francis Abbott (1799-1883). In *Australian Dictionary of Biography. Volume 3:1851-1890. A-C.* Melbourne, Melbourne University Press. Pp. 2-3.

Royal Society of Tasmania, 1901-1902. *Council Minutes.*

Royal Society of Tasmania, 1918. *Council Minutes.*

Royal Society of Tasmania (Northern Branch), 1984. *Earth Tremors. Proceedings of a Seminar commemorating the Centenary of Instrumental Seismology in Australia.* Launceston, Royal Society of Tasmania (Northern Branch).

Russell, H. C., 1872. The coloured cluster about Kappa Crucis. *Transactions of the Royal Society of New South Wales*:1-12.

Scott, H.H., and Scott, E. O. G., 1935. Not astronomy. *The Examiner,* 20 September.

Tebbutt, J., 1885. Notes on Comet Ross. Inserted in *Letters to J. Tebbutt 1885.*

Tebbutt, J., 1908. *Astronomical Memoirs . . .* Sydney, printed for the author.

Todd, D. P., 1881. The solar parallax as derived from the American photographs of the Transit of Venus, 1874, December 8-9. *American Journal of Science* 21:491-493.

University of Tasmania, 1918. *Council's Minutes. Registrar's Correspondence.* University of Tasmania:UT.47/175.

Walch's Tasmanian Almanac. Various editions.

White, G., 1979. John Tebbutt and the astronomy at Windsor Observatory. *Proceedings of the Astronomical Society of Australia* 3(5-6):408-411.

Whitfield, E., n.d. *History of the Launceston Mechanics' Institute and Public Library (Incorporated).* Launceston, Mechanics Institute.

Wild, J. P., 1972. The beginnings of radio astronomy in Australia. *Records of the Australian Academy of Science* 2(3):52-61.

Wood, H., 1973. *Astronomy in Australia.* Sydney, Government Printer.